JC20 Rec'd PCT/PTO 18 MAR 2002

| FORM PTO-1390 (REV. 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | ATTORNEY'S DOCKET NUMBER **10191/2344** |
|---|---|
| **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371** | U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 10/088383 |

| INTERNATIONAL APPLICATION NO. | INTERNATIONAL FILING DATE | PRIORITY DATE CLAIMED. |
|---|---|---|
| **PCT/DE00/03249** | **18 September 2000 (18.09.00)** | **18 September 1999 (18.09.99)** |

TITLE OF INVENTION
MULTI-VOLTAGE ON-BOARD ELECTRICAL SYSTEM

APPLICANT(S) FOR DO/EO/US
**Wunibald FREY, Dr. Ralf HADELER, Thomas HILS, Rainer TOPP, Torsten MOHR, Joerg JEHLICKA, and Marcus KNEIFEL**

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau)
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have. been transmitted by the International Bureau.
   c. ☐ have not been made, however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5))

**Items 11. to 16. below concern other document(s) or information included:**

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
13. ☒ A **FIRST** preliminary amendment.
14. ☒ A substitute specification and marked-up version thereof
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Search Report (translated), Preliminary Examination Report (translated) and PCT/RO/101

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| U.S. APPLICATION NO (if known, see 37 C.F.R.1.5) 10/088383 | INTERNATIONAL APPLICATION NO PCT/DE00/03249 | ATTORNEY'S DOCKET NUMBER 10191/2344 |
|---|---|---|

17. ☒ The following fees are submitted:

**Basic National Fee (37 CFR 1.492(a)(1)-(5)):**

Search Report has been prepared by the EUROPEAN PATENT OFFICE or JPO . . . . . . . . $890.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) . . . . . . $710.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) . . . . . . $740.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO . . . . . . $1,040.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) . . . . . . $100.00

| | | | | CALCULATIONS | PTO USE ONLY |
|---|---|---|---|---|---|
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | | | | $ 890 | |
| Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | | | | $ | |
| Claims | Number Filed | Number Extra | Rate | | |
| Total Claims | 16 - 20 = | 0 | X $18.00 | $ 0 | |
| Independent Claims | 1 - 3 = | 0 | X $84.00 | $ 0 | |
| Multiple dependent claim(s) (if applicable) | | | + $280.00 | $ | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $ 890 | |
| Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28). | | | | $ | |
| **SUBTOTAL =** | | | | $ 890 | |
| Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). + | | | | $ | |
| **TOTAL NATIONAL FEE =** | | | | $ 890 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property + | | | | $ | |
| **TOTAL FEES ENCLOSED =** | | | | $ 890 | |
| | | | | Amount to be: refunded | $ |
| | | | | charged | $ |

a. ☐ A check in the amount of $____________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$890.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

By: W. Knight (Reg. No. 41,172)

Richard L. Mayer

SIGNATURE

SEND ALL CORRESPONDENCE TO:
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NAME

**Customer No. 26646**

3/13/02

DATE

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JC10 Rec'd PCT/PTO 18 MAR 2002

[10191/2344]

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| Applicant(s) | : | Wunibald FREY et al. |
| Serial No. | : | To Be Assigned |
| Filed | : | Herewith |
| For | : | MULTI-VOLTAGE ON-BOARD ELECTRICAL SYSTEM |
| Art Unit | : | To Be Assigned |
| Examiner | : | To Be Assigned |

Assistant Commissioner
for Patents
Washington, D.C. 20231
Box Patent Application

## PRELIMINARY AMENDMENT AND 37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

### IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

### IN THE DRAWINGS

Please amend the drawings as indicated on the attached red-marked sheets.

### IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to:
--What Is Claimed Is:--.

Please cancel claims 1-12 in the underlying PCT application, without prejudice.

Please add the following new claims:

--13. (New) A multi-voltage on-board electrical system for providing at least a first voltage level and a second voltage level different from ground, comprising:

a generator for generating the first voltage level;

at least one voltage converter for generating the second voltage level from the first voltage level;

a switching arrangement;

consumers that are operable, via the switching arrangement, with one of the first voltage level and the second voltage level; and

an arrangement for providing a short circuit protection, the arrangement configured to at least one of reduce a risk of a short circuit between the first voltage level and the second voltage level and minimize an effect of the short circuit.

14. (New) The multi-voltage on-board electrical system according to claim 13, wherein the arrangement for providing the short circuit protection is further configured to protect an at-risk consumer in an event of the short circuit.

15. (New) The multi-voltage on-board electrical system according to claim 13, wherein the system is a dual-voltage on-board electrical system in a motor vehicle.

16. (New) The multi-voltage on-board electrical system according to claim 15, further comprising:

a first battery having a nominal voltage of 12V; and

a second battery having a nominal voltage of 36V,

wherein at least one of the first battery and the second battery includes an intelligent battery terminal having a preselectable property including an overvoltage disconnect.

17. (New) The multi-voltage on-board electrical system according to claim 13, wherein at least one of the consumers includes at least one microprocessor and is assigned to the at least one voltage converter, and wherein the at least one consumer including the at least one microprocessor distributes electric power.

18. (New) The multi-voltage on-board electrical system according to claim 17, wherein the at least one consumer including the at least one microprocessor is configured to control at least one other signal-power distributor.

19. (New) The multi-voltage on-board electrical system according to claim 13, further comprising:

a central signal-power distributor including another voltage converter, wherein unprotected 36V and 42V lines of the multi-voltage on-board electrical system are combined and are mounted in a spatial proximity to the central signal-power distributor, and one of 12V and 14V lines of the multi-voltage on-board electrical system are installed at a greatest possible distance from the unprotected 36V and 42V lines.

20. (New) The multi-voltage on-board electrical system according to claim 13, further comprising:

a pulse-controlled inverter assigned to the generator to rectify an output voltage of the generator in order to produce a rectified voltage and to supply the rectified voltage to a d.c.-d.c. converter.

21. (New) The multi-voltage on-board electrical system according to claim13, further comprising:

at least one satellite signal-power distributor; and

a master signal-power distributor to one of control and protect the at least one satellite signal-power distributor.

22. (New) The multi-voltage on-board electrical system according to claim 13, wherein at least one of the consumers is configured to carry a current which occurs in an event of the short circuit between the first voltage level and the second voltage level, and thereby lower an overvoltage occurring with respect to a lower voltage level.

23. (New) The multi-voltage on-board electrical system according to claim 13, wherein the switching arrangement applies a voltage to at least one of the consumers associated therewith, the switching arrangement including a current measurement arrangement configured to display the short circuit in an event of an excessively high current.

24. (New) The multi-voltage on-board electrical system according to claim 22, wherein the at least one of the consumers is a power circuit-breaker.

25. (New) The multi-voltage on-board electrical system according to claim 24, wherein the at least one of the consumers is a MOSFET power transistor.

26. (New) The multi-voltage on-board electrical system according to claim 25, further comprising:

a comparator to control the MOSFET power transistor.

27. (New) The multi-voltage on-board electrical system according to claim 25, wherein the MOSFET power transistor is configured to limit a current across two resistors connected in series and the MOSFET power transistor is further configured to conduct the current if a predefinable reference voltage is exceeded.

28. (New) The multi-voltage on-board electrical system according to claim 13, wherein an overall configuration for an electric battery and a power management system is obtained by using an appropriate arrangement for implementing management functions.--.

## Remarks

This Preliminary Amendment cancels claims 1-12 in the underlying PCT application, without prejudice. The Preliminary Amendment also adds new claims 13-28. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked-Up Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT application, PCT/DE00/03249 includes an International Search Report, dated February 12, 2001. A copy of the Search Report is annexed hereto.

The underlying PCT application also includes an International Preliminary Examination Report ("IPER") dated October 18, 2001. A translation of the IPER and the annex thereto is annexed hereto.

Applicants submit that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

By: [signature] (Reg. No. 41,172)

Dated: 3/18/02

By: [signature]

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[10191/2344]

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# MULTI-VOLTAGE ON-BOARD ELECTRICAL SYSTEM

## Background Information

The present invention relates to a multi-voltage on-board electrical system, in particular a multi-voltage on-board electrical system for a motor vehicle according to the definition of the species of the main claim.

## Background Information

In on-board electrical systems having a plurality of electric consumers, e.g., in on-board electrical systems for motor vehicles, there is the problem that a 12V voltage is no longer sufficient for the power supply. Since some of the consumers are to be supplied with a voltage higher than 12V, multi-voltage on-board electrical systems having two different voltage levels have become known - a first voltage level, which is at +12V to ground, and a second voltage level at +36V , these voltages both being nominal voltages. The connection between the two voltage levels is established with the help of a d.c.-d.c. converter.

Such a multi-voltage on-board electrical system in a motor vehicle is described in Unexamined German Patent 198 45 569. The electric power is generated in this on-board electrical system with the help of a three-phase generator which is driven by the engine of the vehicle and delivers an output voltage of 42V (charging voltage). A 36V (nominal voltage) battery is charged with this charging voltage. A 12V battery is supplied with a charging voltage of 14V via a d.c.-d.c. converter.

The electric consumers may be connected to the two batteries via suitable switches, the 12V battery supplying the traditional on-board electrical system consumers, e.g., incandescent lamps, while the 36V battery is used to supply high-power consumers, e.g., defrosters. With the known on-board electrical system, the negative terminals of the two batteries are at the same ground potential. Unexamined German Patent 198 45 569 does not describe any measures for preventing a short circuit between the 12V and 36V voltage level or the 14V and 42V voltage level.

Advantages of the Invention

The on-board electrical system according to the present invention having the features of Claim 1 has the advantage that the possibilities for a short circuit occurring between the two voltage levels are largely avoided. However, if a short circuit does occur between the two voltage levels, its effects are attenuated and it is indicated or corrected as soon as possible. At the same time, the consumers supplied with the lower voltage are advantageously protected from the effects of the short circuit.

These advantages are achieved by designing a multi-voltage on-board electrical system having the features of Claim 1 so that means for short-circuit protection are provided between the two voltage levels, these means preventing a short circuit while also reducing the potential differences between the two voltage levels if a short circuit should nevertheless occur. The means for short-circuit protection also include measuring devices which may determine load currents. By analyzing the currents measured, it is possible to localize a short circuit and indicate it through suitable display means.

Additional advantages of the present invention are achieved through the measures characterized in the subclaims. These measures yield the advantage of minimizing the points where an

unprotected short circuit may occur; this is achieved, for example, by reducing the line length and through suitable combination of consumers of the same voltage level. In addition, short circuits are detected rapidly to advantage and are eliminated by shutting down the 36V or 42V consumer at the voltage source. During the time until shutdown of the driving 36V or 42V consumer, the low-voltage system is protected by design measures, e.g., by an overvoltage protection or by removing the higher voltage via robust consumers. Such robust consumers, which withstand voltages even higher than 12V, include, for example, electric heaters or the 12V or 14V battery itself. By reducing the unprotected 36V or 42V lines through a suitable combination of voltage converter and signal-power distributor (SLV), it is possible to further reduce the short-circuit probability in an advantageous manner; the same thing is also true of a design featuring a spatial proximity of signal-power distributor (SLV) and 36V or 42V battery.

Another advantageous possibility of reducing the probability of a short-circuit is to protect the unprotected 42V lines via additional signal-power distributors (satellite signal-power distributors (satellite SLV)) and d.c.-d.c. converters via a master-signal-power distributor system (master SLV).

The on-board electrical system according to the present invention yields the possibility of an overall concept for a multi-voltage on-board electrical system in an advantageous manner, having a battery fuse protection even in the event of a crash and fuse protection for the lower (14V) subsystem for the event of a short circuit between the two subsystems. Even in the event of a short circuit, consequential damage with regard to the battery is avoided in an advantageous manner. It is also advantageous that a "healthy battery" is ensured by bracketing the 14V subsystem while it simultaneously functions as a sacrificial consumer to secure the overcurrent in the event of a short circuit. Self-sensing line switches (e.g.,

sensfets) in the 42V subsystem are advantageous for short-circuit detection and shutdown.

Use of an active voltage limitation having a MOS output stage is also advantageous and makes it possible to eliminate the additional complexity in polarity reversal.

Drawing

Embodiments of the present invention are illustrated in the drawing and explained in greater detail in the following description. Specifically, Figure 1 shows as an example a dual-voltage on-board electrical system in the case of a short circuit between the two voltage levels; Figure 2 shows a first simple on-board electrical system architecture; Figure 3 shows an expanded on-board electrical system architecture, which is improved in comparison with that shown in Figure 2, and Figure 4 shows a diagram of an overall concept having battery fuse protection for the event of a crash and of a short-circuit. Figure 5 shows an example of another protective circuit.

Description

Figure 1 shows a schematic block diagram of the components of a dual-voltage on-board electrical system of a motor vehicle which are essential for an understanding of the present invention. Specifically, generator G, e.g., a claw-pole three-phase generator driven by the vehicle engine is shown. Generator G delivers an output voltage U0 of 42V, for example, which is used directly to charge battery B1 having a nominal voltage of 36V. The line resistance between generator G and battery B1 is symbolized by resistors R1 and R2. The consumers that are to be supplied with voltage U0 are connected to generator G via signal-power distributor V1. Specifically, three consumers R6, R7 and R8 are shown, connectable to generator G over semiconductor switches H1, H2 and H3, for example. According to the design, these semiconductor switches

H1, H2 and H3 have inverse diodes D1, D2 and D3 and internal resistors R3, R4 and R5.

A second battery B2 is charged by generator G via a d.c.-d.c. converter W1. D.c.-d.c. converter W1 converts voltage U0=42V into a voltage U1=14V suitable for charging battery B2 having a nominal voltage of 12V. Voltage U1 is supplied by voltage converter W1 to battery B2 via switch S1 and the line having line resistance R9. Resistance R9 also includes the internal resistance of battery B2.

Battery B2 supplies consumers which require a lower voltage, e.g., 12V or 14V. The connection is via signal-power distributor V2. These consumers are labeled as R13, R14 and R15 and may be connected to the system via semiconductor switches H4, H5 and H6 having inverse diodes D4, D5 and D6, respectively. The line resistances between consumers R13, R14 and R15 are labeled as R10, R11 and R12.

The consumers that are to be supplied with 12V or 14V over SLV V2 also include the series connection of a Zener diode Z1 and another diode D7, which together form an overvoltage protection.

The consumers for one or the other voltage level are selected according to the voltage requirements for their optimal operation. The starter may be connected either to the 12V battery or the 36V battery, for example.

When using semiconductor switches on the 14V side, the switch having the short-circuited 14V load becomes conducting via the inverse diode, which is always present, of the respective semiconductor switch and thus connects all the 14V consumers to 42V, so there is a risk to the consumers that are not designed for the higher voltage. Figure 1 illustrates such a short circuit. A resistor RK situated on the voltage side between resistors R8 and R13 represents a short circuit which

is either to be avoided according to the present invention or whose effects are at least to be mitigated. How a short circuit symbolized by resistor R16 may be prevented or its effects minimized will be explained in greater detail below.

Figure 2 illustrates another embodiment of an on-board electrical system architecture. This again shows generator G, but in addition Figure 2 also indicates the regulation of the generator with the help of pulse-controlled inverter elements, which are designed as a pulse-controlled inverter bridge PWR for a three-phase generator in a known manner. In this case, voltage U0 occurs at the output of pulse-controlled inverter bridge PWR. Voltage U0 is supplied to various components of the on-board electrical system according to Figure 2, the connection of these components being at a point P1 in the selected embodiment. At this point P1, intelligent battery terminal IBK1 is connected via which battery B1 is supplied with voltage U0. In addition, consumers V1 may also be connected directly to intelligent battery terminal IBK1 and thus connected to battery B1. From point P1, d.c.-d.c. converter W1 and signal-power distributors SLV1, SLV2 through SLVn are also supplied with voltage U0, and they may in turn supply other consumers, only consumers R16, R17 and R18 of which are shown here. At the input, the signal-power distributors (SLV) are interconnected on the 36V and 12V side or on the 42V and 14V side, so they are connected in parallel to voltage converter W1. At the output, the signal-power distributors supply power supply voltage U0 and U1 for consumers R16, R17, R18 and R19, R20, R21, respectively.

The low-voltage side of voltage converter W1 on which voltage U1 is 12V or 14V leads over intelligent battery terminal IBK2 to battery B2. Additional consumers V2 may be connected via switch S3 to intelligent battery terminal IBK2 having overvoltage protection and thus directly to battery B2.

The actual 42V and 14V voltage levels are formed by the

corresponding sides of the signal-power distributors having respective consumers R16, R17 and R18 symbolically for the 42V voltage level and R19, R20 and R21 symbolically for the consumers of the 14V voltage level.

The example of an on-board electrical system architecture illustrated in Figure 2 is a standard design which is improved with the arrangement illustrated in Figure 3. The difference between the embodiment according to the present invention as illustrated in Figure 3 and that according to Figure 2 is that voltage converter W1 and signal-power distributor SLV1 are combined and form converter W2. Signal-power distributor SLV1 of converter W2 is then connected to other signal-power distributors SLV2 through SLVn and thus forms a master SLV which protects satellite signal-power distributors SLV2 through SLVn. The satellite SLV may have their own d.c.-d.c. converters, the SLV and the d.c.-d.c. converters then being combined at least in part. The signal-power distributors include, if necessary, a separate microprocessor which performs the required control measures automatically.

In the embodiment according to Figure 3, for example, voltage converter W1 is combined with signal-power distributor SLV1 to form a common component W2. Signal-power distributor SLVn is assigned its own d.c.-d.c. converter DC/DCn, and signal-power distributor SLV2 is supplied with power and controlled directly by signal-power distributor SLV1. There are also other possible connections to the signal-power distributors. The other components of the on-board electrical system of the embodiment according to Figure 3 correspond to the embodiment according to Figure 2.

As shown in Figure 1, additional faults or short circuits may occur in a dual-voltage on-board electrical system, e.g., in an on-board electrical system having 14V/42V voltage levels to ground, in addition to the known short circuits to ground, namely short circuits between 14V and 42V. If, as shown in

Figure 1, semiconductor switches H1 through H6 are used for connecting consumers to the system or disconnecting them, inverse diodes D1 through D6 are automatically also present and must be taken into account. When using semiconductor switches having inverse diodes on the 14V side, the switch having the short-circuited 14V consumer becomes conducting via the respective inverse diode and connects all 14V loads to 42V. All 14V consumers are thus at 42V in the case of a single short circuit and are at risk because they are not usually designed for this. Thus, the possibility of a 14V/42V short circuit is to be reduced according to the present invention, and in the event a short circuit nevertheless occurs, at least the 14V consumers are to be protected. A few protective measures are achieved by design features in the on-board electrical system illustrated in Figure 2, but the most advantageous embodiment according to the present invention of an on-board electrical system architecture with which all the advantages of this invention may be achieved is illustrated in Figure 3.

In an arrangement according to the on-board electrical system architecture illustrated in Figure 2, various lines may lead from the 36V or 42V battery B1 to generator G, d.c.-d.c. converter W1 and signal-power distributors SLV1 through SLVn. These lines are not protected by any switches or fuses except for intelligent battery terminal IBK1. A short circuit of one of these lines to a 14V consumer R19, R20, R21 or V2 cannot be corrected by a shutdown on 42V, but there is the possibility of performing the shutdown of the battery via intelligent battery terminal IBK1; however, then the entire on-board electrical system is shut down. Since signal-power distributors SLV1 through SLVn are usually distributed over the entire vehicle and are situated in the engine space, the cockpit or the trunk, for example, this results in substantial cable lengths which result in a relatively high probability of a short circuit.

A first measure to reduce the probability of a short circuit on unprotected 42V lines is to combine them with, or at least guarantee their spatial proximity to, a central signal-power distributor SLV1 having d.c.-d.c. converter W1 or an additional d.c.-d.c. converter. This forms a new control unit within which the lines and plugs are designed so that the 14V areas and the 42V areas are separated by the maximum possible distance.

A second measure is the spatial proximity of the battery and the respective d.c.-d.c. converter combination. As an alternative to that, pulse-controlled inverter PWR of generator G may be combined with d.c.-d.c. converter W1 or at least a spatial proximity between these parts may be guaranteed.

A third measure which is made possible with the embodiment according to Figure 3 is to connect the additional signal-power distributors not directly to the battery but instead to protect them as satellite signal-power distributors by a master signal-power distributor.

As an alternative, central or decentralized, locally distributed d.c.-d.c. converters may also be used to supply the 14V side of the on-board electrical system. Decentralized d.c.-d.c. converters reduce the length of unprotected 14V lines and thus also reduce the probability of these lines coming in contact with 42V lines. If this alternative is selected, the protection may in turn be implemented via the master signal-power distributor, and the d.c.-d.c. converter may be combined with a satellite signal-power distributor to form a separate control system. All these measures contribute toward reducing the probability of a short circuit. However, if a short circuit nevertheless occurs, at least measures are initiated to reduce the effects of the short circuit according to the present invention.

In the case of a 14V/42V short circuit such as that illustrated in Figure 1, the 42V power supply voltage is first applied to the short-circuited 14V consumer. Then the 42V voltage is applied via the respective inverse diode of the semiconductor switch in the signal-power distributor to all 14V switches, which are protected from the overvoltage by switching through. Therefore, after a short period of time, a voltage of 42V is applied to the disconnected 14V consumers, but this voltage may result in damage to the consumers if no countermeasures are taken. One possibility of preventing this damage is to use reverse current-protected switches instead of semiconductor switches having inverse diodes, in which case, however, it becomes difficult to locate the short circuit on 42V.

Another alternative in the event of a short circuit is to connect a strong 14V consumer ("sacrificial consumer"), e.g., one of resistors R19, R20, R21, and to implement a targeted reduction in the resulting voltage in the system. The high current established due to the sacrificial consumer, which also flows through the supplying 42V consumer, offers the possibility of actively detecting the supplying consumer by detecting the overcurrent with the help of a current measurement. After detection of the consumer, it may be disconnected or with the help of an implemented fuse function, a targeted shutdown may be performed on the 42V consumer. Shutdown of the supplying 42V load is in any case the response which repairs the system in the most effective and efficient manner.

To detect the overcurrent in the supplying 42V load, i.e., 42V consumer, the current through the 42V may be sensed in the signal-power distributor, e.g., in the master SLV in a lower-level program loop in a very short clock cycle, and if an overcurrent is detected, a disconnect may be performed. The shorter the period of time between the occurrence of the fault and disconnection of the supplying load, the shorter is the

time during which an overvoltage occurs at the 14V consumers and an undervoltage at the 42V consumers.

If the short circuit has occurred at a 42V consumer which is supplied with power by a satellite signal-power distributor SLV, the master signal-power distributor SLV must not disconnect the line to satellite SLV immediately, but instead it must allow time for correction of the fault. If this does not occur within a specified period of time, the master SLV must nevertheless disconnect the satellite SLV because then the short circuit has presumably occurred on the supply line of the satellite SLV.

Since this period of time is not infinitely short, the sacrificial consumer should be designed accordingly so that it is not damaged by the overvoltage or the resulting current. One possibility is to insert an overvoltage protection element such as an active surge voltage protector similar to a load-dump protector which keeps the voltage within a defined range.

An alternative is to use the 12V battery as a sacrificial consumer. The 12V and 36V battery (nominal voltage) must be designed accordingly, so that neither battery is damaged for the period of time required for detection and disconnection of the supplying load, and so that the voltage in the system is able to stabilize at a level that will not damage either the consumers of the 42V voltage level or those of the 14V voltage level.

Figure 4 shows another overall concept of an on-board electrical system. This on-board electrical system which is designed as a 14/42 volt on-board electrical system (charging voltage), i.e., a 12/36 volt system (nominal voltage) includes a back-up fuse concept, a battery state monitor, preferably integrated into the power management, and an overcurrent disconnect integrated into the individual switches of the 42V subsystem.

The overall design having electrical battery management (EBM) and electrical power management (EEM) has a generator G which may also be designed as a starter/generator and preferably includes bidirectional d.c.-d.c. converters, a battery back-up fuse concept, a power management and signal-power distributor (SLV) for the 14V and 42V subsystems. The 14V subsystem also includes a starter St which is needed if only a generator is connected to 42V, or an auxiliary starter HSt, which is sufficient in the case of a starter/generator at 42V. Starter St should be designed for an external start and the auxiliary starter should be designed to support the starter/generator in the case of low-temperature start.

The back-up fuse design has one unit per battery, and it should be situated close to the B+ terminal (B+ pin) of the battery or in its immediate proximity. It contains fuses to the generator or the starter/generator or starter St, an electronic switch to the on-board electrical system and components for detection of the parameters of the battery status (charge status SOC and age of the battery SOH). The actually battery status calculation is preferably performed in the power management system, in addition to its actual function of protecting the battery charge state in both subsystems by influencing the drive train and consumers. All the components communicate with one another over a vehicle body bus (e.g. a CAN bus). The overall coordination is integrated into the power management system.

With the back-up fuse design described here, one compact unit may advantageously have integrated into it the actual back-up fuses for the generator and the d.c.-d.c. converters and starters, the switches for disconnecting the on-board electrical system in the event of a crash (activated by the airbag via the CAN) and components for detecting the battery status (IB, UB, TB). Because of the selected arrangement, no inversely switched additional power circuit-breakers are needed, so the voltage drop across the semiconductor switch,

preferably a power MOSFET, is lower.

Another important feature of the overall fuse design is contained in the switches (SLV) of the 42V subsystem. They are designed as sensfets, for example. The actual overcurrent detection is to be designed as HW, so this guarantees that a disconnection of the short-circuit path in the 42V subsystem in the microsecond range is possible. This is important so that the 14V components affected by the short circuit are reliably protected.

The 12/14-volt battery whose state is monitored is capable of reliably bracketing the 14V subsystem at a harmless level until shutdown on the 42-volt side occurs. In addition, this guarantees that a definitely detectable overcurrent in the shorted circuit will occur in the event of a short circuit, regardless of the instantaneous load situation.

Figure 5 shows a protective circuit in which a power transistor 4, preferably a MOSFET switching transistor having an integrated free-wheeling diode 7 is used. Power transistor 4 is controlled by a comparator 1 whose one input 6 receives a reference voltage Uref. Second input 5 of comparator 1 is connected between the series connection of resistors 2 and 3, resistor 2 being connected to terminal KL30 and resistor 3 being connected to terminal KL31. Terminal KL30 corresponds to the 12V or 14V terminal of a conventional on-board electrical system, while terminal KL31 corresponds to the ground line.

The mode of operation of the circuit may be explained as follows. The voltage on the 14V terminal is sent to ground terminal KL31 over the voltage divider having resistors 2 and 3. The voltage applied between two resistors 2 and 3 is measured and sent to the input of comparator 1 and compared with reference voltage Uref. Voltage U2 at resistor 3 drops as a function of the current flowing across resistors 2, 3,. If this voltage U2 sent to comparator 1 exceeds preselectable

reference voltage Uref, power transistor 4 which is activated becomes conducting and therefore limits the voltage to the level defined by resistors 2 and 3. A certain voltage may thus be preselected through the choice of resistors 2 and 3. Power transistor 4 thus forms an active voltage limiter.

If the on-board electrical system is supplied with a negative voltage, reverse diode 7 of charging voltage is switched to conducting. Then the threshold voltage of reverse diode 7 is established as the maximum negative voltage in the on-board electrical system. This value may be preselected. The reverse diode thus assumes a protective function, which has the advantage in comparison with a possible combination with a Zener diode that a narrower tolerance band may be established for the voltage. The circuit in Figure 5 makes it possible to limit a short circuit as well as negative voltages to advantage.

What is claimed is:

1. A multi-voltage on-board electrical system having at least two voltage levels having two voltages different from ground, having a generator which generates one of the voltages and at least one voltage converter which generates the second voltage from the first voltage, having consumers that are operable with one of the voltages via switching means,
wherein means for short circuit protection are provided, reducing the risk of a short circuit and/or minimizing the effects of a short circuit between the two voltages and optionally protecting at-risk consumers in the event of a short circuit.

2. The multi-voltage on-board electrical system according to Claim 1,
wherein said system is a dual-voltage on-board electrical system in a motor vehicle; there is a first battery having a nominal voltage of 12V and a second battery having a nominal voltage of 36V, and a terminal of at least one of the batteries remote from ground is designed as an intelligent battery terminal which has the preselectable properties and in particular includes an overvoltage disconnect.

3. The multi-voltage on-board electrical system according to Claim 1 or 2,
wherein at least one signal-power consumer which includes at least one microprocessor is assigned to the voltage converter W1, and it assumes the function of distributing the electric power and optionally controls other signal-power distributors.

4. The multi-voltage on-board electrical system according to one of the preceding claims,
wherein the unprotected 36V and 42V lines are combined and are mounted in spatial proximity to a central signal-power distributor, in particular having a voltage converter, and the lines of the 12V or 14V on-board electrical system are

installed at the greatest possible distance from those of the 36V or 42V on-board electrical system.

5. The multi-voltage on-board electrical system according to one of the preceding claims,
wherein a pulse-controlled inverter is assigned to the generator to rectify the output voltage of the generator and to supply the rectified voltage to a d.c.-d.c. converter.

6. The multi-voltage on-board electrical system according to one of the preceding claims,
wherein the signal-power distributors are designed as satellite signal-power distributors which are controlled and/or protected by a master signal-power distributor.

7. The multi-voltage on-board electrical system according to one of the preceding claims,
wherein at least one of the consumers is designed so that it is capable of carrying the current which occurs in the event of a short circuit between the two voltage levels and thus lowers the overvoltage occurring with respect to the lower voltage level.

8. The multi-voltage on-board electrical system according to one of the preceding claims,
wherein at least one switching means via which voltage is applicable to at least one consumer associated with it has means for current measurement, said means displaying a short circuit in the event of an excessively high current.

9. The multi-voltage on-board electrical system according to one of Claims 7 or 8,
wherein the at least one consumer is a power circuit-breaker, in particular a MOSFET power transistor (4).

10. The multi-voltage on-board electrical system according to Claim 9,

wherein the power transistor (4) is controllable by a comparator (1).

11. The multi-voltage on-board electrical system according to Claim 9 or 10,
wherein the power transistor (4) is switched to conducting if a predefinable reference voltage (Uref) is exceeded and it limits the current across two resistors (2, 3) connected in series.

12. The multi-voltage on-board electrical system according to one of the preceding claims,
wherein an overall design for an electric battery and power management system is obtained by using appropriate means for implementing the management functions.

Abstract of the Disclosure

A multi-voltage on-board electrical system having at least two voltages different from ground, e.g., 14V and 42V, is described, in which a generator, e.g., the electric generator of a vehicle, generates one of the voltages, and the other voltage is formed from the first voltage by a converter. The two voltages are used to supply two different d.c. systems. Means are provided as short-circuit protection between the two voltage levels, largely reducing the risk of a short circuit and/or the effects of a short circuit between the two voltages and/or protecting or disconnecting at-risk consumers in the event of a short circuit. In addition to the short-circuit protection, an overall concept of an electric battery and power management system may also be obtained for the multi-voltage on-board electrical system.

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# MULTI-VOLTAGE ON-BOARD ELECTRICAL SYSTEM

## FIELD OF THE INVENTION

The present invention relates to a multi-voltage on-board electrical system, in particular a multi-voltage on-board electrical system for a motor vehicle.

## BACKGROUND INFORMATION

In on-board electrical systems having a plurality of electric consumers, e.g., in on-board electrical systems for motor vehicles, there may be a problem in that a 12V voltage is no longer sufficient for the power supply. Since some of the consumers may be supplied with a voltage higher than 12V, multi-voltage on-board electrical systems having two different voltage levels have become conventional - a first voltage level, which is at +12V to ground, and a second voltage level at +36V , these voltages both being nominal voltages. The connection between the two voltage levels may be established with the help of a d.c.-d.c. converter.

Such a multi-voltage on-board electrical system in a motor vehicle is described in German Published Patent Application No. 198 45 569. The electric power may be generated in this on-board electrical system with the help of a three-phase generator which may be driven by the engine of the vehicle and may deliver an output voltage of 42V (charging voltage). A 36V (nominal voltage) battery may be charged with this charging voltage. A 12V battery may be supplied with a charging voltage of 14V via a d.c.-d.c. converter.

The electric consumers may be connected to the two batteries via suitable switches, the 12V battery supplying the traditional on-board electrical system consumers, e.g., incandescent lamps, while the 36V battery may be used to

supply high-power consumers, e.g., defrosters. With the conventional on-board electrical system, the negative terminals of the two batteries may be at the same ground potential. German Published Patent Application No. 198 45 569 may not describe any measures for preventing a short circuit between the 12V and 36V voltage level or the 14V and 42V voltage level.

SUMMARY OF THE INVENTION

An on-board electrical system according to the present invention may largely avoid a short circuit occurring between the two voltage levels. However, if a short circuit does occur between the two voltage levels, its effects may be attenuated and it may be indicated or corrected as soon as possible. At the same time, the consumers supplied with the lower voltage may be protected from the effects of the short circuit.

This may be achieved by configuring a multi-voltage on-board electrical system so that an arrangement for short-circuit protection is provided between the two voltage levels, the arrangement preventing a short circuit while also reducing the potential differences between the two voltage levels if a short circuit should nevertheless occur. The arrangement for short-circuit protection may also include measuring devices which may determine load currents. By analyzing the currents measured, it may be possible to localize a short circuit and indicate it through suitable a display arrangement.

The present invention may include measures to minimize the points where an unprotected short circuit may occur. This may be achieved, for example, by reducing the line length and through suitable combination of consumers of the same voltage level. In addition, short circuits may be detected rapidly and may be eliminated by shutting down the 36V or 42V consumer at the voltage source. During the time until shutdown of the driving 36V or 42V consumer, the low-voltage system may be protected by design measures, e.g., by an overvoltage

protection or by removing the higher voltage via robust consumers. Such robust consumers, which withstand voltages even higher than 12V, may include, for example, electric heaters or the 12V or 14V battery itself. By reducing the unprotected 36V or 42V lines through a suitable combination of voltage converter and signal-power distributor (SLV), the probability of a short circuit may be further reduced. The same thing may also apply to a configuration featuring a spatial proximity of signal-power distributor (SLV) and 36V or 42V battery.

The probability of a short-circuit may also be reduced by protecting the unprotected 42V lines via additional signal-power distributors (satellite signal-power distributors (satellite SLV)) and d.c.-d.c. converters via a master-signal-power distributor system (master SLV).

An on-board electrical system according to the present invention may yield an overall concept for a multi-voltage on-board electrical system, having a battery fuse protection even in the event of a crash and fuse protection for the lower (14V) subsystem for the event of a short circuit between the two subsystems. Even in the event of a short circuit, consequential damage with regard to the battery may be avoided. A "healthy battery" may be ensured by bracketing the 14V subsystem while it may simultaneously function as a sacrificial consumer to secure the overcurrent in the event of a short circuit. Self-sensing line switches (e.g., sensfets) in the 42V subsystem may be used for short-circuit detection and shutdown.

Use of an active voltage limitation having a MOS output stage may eliminate the additional complexity in polarity reversal.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows as an example of a dual-voltage on-board electrical system in the case of a short circuit between the two voltage levels.

Figure 2 shows a first simple on-board electrical system architecture.

Figure 3 shows an expanded on-board electrical system architecture, which may be improved in comparison with that shown in Figure 2.

Figure 4 shows a diagram of an overall concept having battery fuse protection for the event of a crash and of a short-circuit.

Figure 5 shows an example of another protective circuit.

DETAILED DESCRIPTION

Figure 1 shows a schematic block diagram of the components of a dual-voltage on-board electrical system of a motor vehicle which may be essential for an understanding of the present invention. Specifically, generator G, e.g., a claw-pole three-phase generator driven by the vehicle engine is shown. Generator G delivers an output voltage U0 of 42V, for example, which is used directly to charge battery B1 having a nominal voltage of 36V. The line resistance between generator G and battery B1 is symbolized by resistors R1 and R2. The consumers that are to be supplied with voltage U0 are connected to generator G via signal-power distributor V1. Specifically, three consumers R6, R7 and R8 are shown, connectable to generator G over semiconductor switches H1, H2 and H3, for example. According to the design, these semiconductor switches H1, H2 and H3 have inverse diodes D1, D2 and D3 and internal resistors R3, R4 and R5.

A second battery B2 is charged by generator G via a d.c.-d.c. converter W1. D.c.-d.c. converter W1 converts voltage U0=42V into a voltage U1=14V suitable for charging battery B2 having a nominal voltage of 12V. Voltage U1 is supplied by voltage converter W1 to battery B2 via switch S1 and the line having line resistance R9. Resistance R9 also includes the internal resistance of battery B2.

Battery B2 supplies consumers which require a lower voltage, e.g., 12V or 14V. The connection is via signal-power distributor V2. These consumers are labeled as R13, R14 and R15 and may be connected to the system via semiconductor switches H4, H5 and H6 having inverse diodes D4, D5 and D6, respectively. The line resistances between consumers R13, R14 and R15 are labeled as R10, R11 and R12.

The consumers that are to be supplied with 12V or 14V over SLV V2 also include the series connection of a Zener diode Z1 and another diode D7, which together form an overvoltage protection.

The consumers for one or the other voltage level are selected according to the voltage requirements for their optimal operation. The starter may be connected either to the 12V battery or the 36V battery, for example.

When using semiconductor switches on the 14V side, the switch having the short-circuited 14V load becomes conducting via the inverse diode, which is always present, of the respective semiconductor switch and thus connects all the 14V consumers to 42V, so there is a risk to the consumers that are not designed for the higher voltage. Figure 1 illustrates such a short circuit. A resistor RK situated on the voltage side between resistors R8 and R13 represents a short circuit which is either to be avoided according to the present invention or whose effects are at least to be mitigated. How a short circuit symbolized by resistor R16 may be prevented or its

effects minimized will be explained in greater detail below.

Figure 2 illustrates another example embodiment of an on-board electrical system architecture. This again shows generator G, but in addition Figure 2 also indicates the regulation of the generator with the help of pulse-controlled inverter elements, which are designed as a pulse-controlled inverter bridge PWR for a three-phase generator in a conventional manner. In this case, voltage U0 occurs at the output of pulse-controlled inverter bridge PWR. Voltage U0 is supplied to various components of the on-board electrical system according to Figure 2, the connection of these components being at a point P1 in the selected example embodiment. At this point P1, intelligent battery terminal IBK1 is connected via which battery B1 is supplied with voltage U0. In addition, consumers V1 may also be connected directly to intelligent battery terminal IBK1 and thus connected to battery B1. From point P1, d.c.-d.c. converter W1 and signal-power distributors SLV1, SLV2 through SLVn are also supplied with voltage U0, and they may in turn supply other consumers, only consumers R16, R17 and R18 of which are shown here. At the input, the signal-power distributors (SLV) are interconnected on the 36V and 12V side or on the 42V and 14V side, so they are connected in parallel to voltage converter W1. At the output, the signal-power distributors supply power supply voltage U0 and U1 for consumers R16, R17, R18 and R19, R20, R21, respectively.

The low-voltage side of voltage converter W1 on which voltage U1 is 12V or 14V leads over intelligent battery terminal IBK2 to battery B2. Additional consumers V2 may be connected via switch S3 to intelligent battery terminal IBK2 having overvoltage protection and thus directly to battery B2.

The actual 42V and 14V voltage levels are formed by the corresponding sides of the signal-power distributors having respective consumers R16, R17 and R18 symbolically for the 42V voltage level and R19, R20 and R21 symbolically for the

consumers of the 14V voltage level.

The example of an on-board electrical system architecture illustrated in Figure 2 may be a standard configuration which may improved with the arrangement illustrated in Figure 3. The difference between the example embodiment according to the present invention as illustrated in Figure 3 and that according to Figure 2 is that voltage converter W1 and signal-power distributor SLV1 are combined and form converter W2. Signal-power distributor SLV1 of converter W2 is then connected to other signal-power distributors SLV2 through SLVn and thus forms a master SLV which protects satellite signal-power distributors SLV2 through SLVn. The satellite SLV may have their own d.c.-d.c. converters, the SLV and the d.c.-d.c. converters then being combined at least in part. The signal-power distributors may include a separate microprocessor which performs the required control measures automatically.

In the example embodiment according to Figure 3, for example, voltage converter W1 is combined with signal-power distributor SLV1 to form a common component W2. Signal-power distributor SLVn is assigned its own d.c.-d.c. converter DC/DCn, and signal-power distributor SLV2 is supplied with power and controlled directly by signal-power distributor SLV1. There may also be other possible connections to the signal-power distributors. The other components of the on-board electrical system of the embodiment according to Figure 3 correspond to the embodiment according to Figure 2.

As shown in Figure 1, additional faults or short circuits may occur in a dual-voltage on-board electrical system, e.g., in an on-board electrical system having 14V/42V voltage levels to ground, in addition to the short circuits to ground, namely short circuits between 14V and 42V. If, as shown in Figure 1, semiconductor switches H1 through H6 are used for connecting consumers to the system or disconnecting them, inverse diodes D1 through D6 are also present and may need to be taken into

account. When using semiconductor switches having inverse diodes on the 14V side, the switch having the short-circuited 14V consumer becomes conducting via the respective inverse diode and connects all 14V loads to 42V. All 14V consumers are thus at 42V in the case of a single short circuit and may be at risk because they are not usually configured for this. Thus, the possibility of a 14V/42V short circuit may be reduced according to the present invention, and in the event a short circuit nevertheless occurs, at least the 14V consumers may be protected. A few protective measures may be achieved by design features in the on-board electrical system illustrated in Figure 2. An example embodiment according to the present invention of an on-board electrical system architecture is illustrated in Figure 3.

In an arrangement according to the on-board electrical system architecture illustrated in Figure 2, various lines may lead from the 36V or 42V battery B1 to generator G, d.c.-d.c. converter W1 and signal-power distributors SLV1 through SLVn. These lines are not protected by any switches or fuses except for intelligent battery terminal IBK1. A short circuit of one of these lines to a 14V consumer R19, R20, R21 or V2 may not be corrected by a shutdown on 42V, but the shutdown of the battery may be performed via intelligent battery terminal IBK1. However, then the entire on-board electrical system may be shut down. Since signal-power distributors SLV1 through SLVn are usually distributed over the entire vehicle and are situated in the engine space, the cockpit or the trunk, for example, this may result in substantial cable lengths which may result in a relatively high probability of a short circuit.

A first measure to reduce the probability of a short circuit on unprotected 42V lines is to combine them with, or at least ensure their spatial proximity to, a central signal-power distributor SLV1 having d.c.-d.c. converter W1 or an additional d.c.-d.c. converter. This forms a new control unit

within which the lines and plugs are designed so that the 14V areas and the 42V areas are separated by the maximum possible distance.

A second measure is the spatial proximity of the battery and the respective d.c.-d.c. converter combination. As an alternative to that, pulse-controlled inverter PWR of generator G may be combined with d.c.-d.c. converter W1 or at least a spatial proximity between these parts may be ensured.

A third measure which is made possible with the example embodiment according to Figure 3 is to connect the additional signal-power distributors not directly to the battery but instead to protect them as satellite signal-power distributors by a master signal-power distributor.

As an alternative, central or decentralized, locally distributed d.c.-d.c. converters may also be used to supply the 14V side of the on-board electrical system. Decentralized d.c.-d.c. converters reduce the length of unprotected 14V lines and thus may also reduce the probability of these lines coming in contact with 42V lines. If this alternative is selected, the protection may in turn be implemented via the master signal-power distributor, and the d.c.-d.c. converter may be combined with a satellite signal-power distributor to form a separate control system. All these measures may contribute toward reducing the probability of a short circuit. However, if a short circuit nevertheless occurs, at least measures may be initiated to reduce the effects of the short circuit according to the present invention.

In the case of a 14V/42V short circuit such as that illustrated in Figure 1, the 42V power supply voltage is first applied to the short-circuited 14V consumer. Then the 42V voltage is applied via the respective inverse diode of the semiconductor switch in the signal-power distributor to all 14V switches, which are protected from the overvoltage by

switching through. Therefore, after a short period of time, a voltage of 42V is applied to the disconnected 14V consumers, but this voltage may result in damage to the consumers if no countermeasures are taken. One possibility of preventing this damage is to use reverse current-protected switches instead of semiconductor switches having inverse diodes, in which case, however, it may become difficult to locate the short circuit on 42V.

Another alternative in the event of a short circuit is to connect a strong 14V consumer ("sacrificial consumer"), e.g., one of resistors R19, R20, R21, and to implement a targeted reduction in the resulting voltage in the system. The high current established due to the sacrificial consumer, which also flows through the supplying 42V consumer, offers the possibility of actively detecting the supplying consumer by detecting the overcurrent with the help of a current measurement. After detection of the consumer, it may be disconnected or with the help of an implemented fuse function, a targeted shutdown may be performed on the 42V consumer. Shutdown of the supplying 42V load may be a response which repairs the system in an effective and efficient manner.

To detect the overcurrent in the supplying 42V load, i.e., 42V consumer, the current through the 42V may be sensed in the signal-power distributor, e.g., in the master SLV in a lower-level program loop in a very short clock cycle, and if an overcurrent is detected, a disconnect may be performed. The shorter the period of time between the occurrence of the fault and disconnection of the supplying load, the shorter is the time during which an overvoltage occurs at the 14V consumers and an undervoltage at the 42V consumers.

If the short circuit has occurred at a 42V consumer which is supplied with power by a satellite signal-power distributor SLV, the master signal-power distributor SLV may be required to avoid disconnecting the line to satellite SLV immediately,

but instead it may be required to allow time for correction of the fault. If this does not occur within a specified period of time, the master SLV may nevertheless be required to disconnect the satellite SLV because then the short circuit has presumably occurred on the supply line of the satellite SLV.

Since this period of time is not infinitely short, the sacrificial consumer may be designed accordingly so that it is not damaged by the overvoltage or the resulting current. One possibility may be to insert an overvoltage protection element such as an active surge voltage protector similar to a load-dump protector which keeps the voltage within a defined range.

An alternative is to use the 12V battery as a sacrificial consumer. The 12V and 36V battery (nominal voltage) may be required to be configured accordingly, so that neither battery is damaged for the period of time required for detection and disconnection of the supplying load, and so that the voltage in the system is able to stabilize at a level that will not damage either the consumers of the 42V voltage level or those of the 14V voltage level.

Figure 4 shows another overall concept of an on-board electrical system. This on-board electrical system which is designed as a 14/42 volt on-board electrical system (charging voltage), i.e., a 12/36 volt system (nominal voltage) includes a back-up fuse concept, a battery state monitor, may be integrated into the power management, and an overcurrent disconnect integrated into the individual switches of the 42V subsystem.

The overall design having electrical battery management (EBM) and electrical power management (EEM) includes a generator G which may also be designed as a starter/generator and may include bidirectional d.c.-d.c. converters, a battery back-up fuse concept, a power management and signal-power distributor

(SLV) for the 14V and 42V subsystems. The 14V subsystem may also include a starter St which is needed if only a generator is connected to 42V, or an auxiliary starter HSt, which may be sufficient in the case of a starter/generator at 42V. Starter St may be designed for an external start and the auxiliary starter may be designed to support the starter/generator in the case of low-temperature start.

The back-up fuse configuration includes one unit per battery, and it may be situated close to the B+ terminal (B+ pin) of the battery or in its immediate proximity. It contains fuses to the generator or the starter/generator or starter St, an electronic switch to the on-board electrical system and components for detection of the parameters of the battery status (charge status SOC and age of the battery SOH). The actually battery status calculation may be performed in the power management system, in addition to its actual function of protecting the battery charge state in both subsystems by influencing the drive train and consumers. All the components communicate with one another over a vehicle body bus (e.g. a CAN bus). The overall coordination is integrated into the power management system.

With the back-up fuse design described here, one compact unit may have integrated into it the actual back-up fuses for the generator and the d.c.-d.c. converters and starters, the switches for disconnecting the on-board electrical system in the event of a crash (activated by the airbag via the CAN) and components for detecting the battery status (IB, UB, TB). Because of the selected arrangement, no inversely switched additional power circuit-breakers may be needed, so the voltage drop across the semiconductor switch, e.g. a power MOSFET, is lower.

Another feature of the overall fuse design is contained in the switches (SLV) of the 42V subsystem. They are designed as sensfets, for example. The actual overcurrent detection is to

be designed as HW, so this guarantees that a disconnection of the short-circuit path in the 42V subsystem in the microsecond range is possible. This is important so that the 14V components affected by the short circuit may be reliably protected.

The 12/14-volt battery whose state is monitored may be capable of reliably bracketing the 14V subsystem at a harmless level until shutdown on the 42-volt side occurs. In addition, this ensures that a definitely detectable overcurrent in the shorted circuit will occur in the event of a short circuit, regardless of the instantaneous load situation.

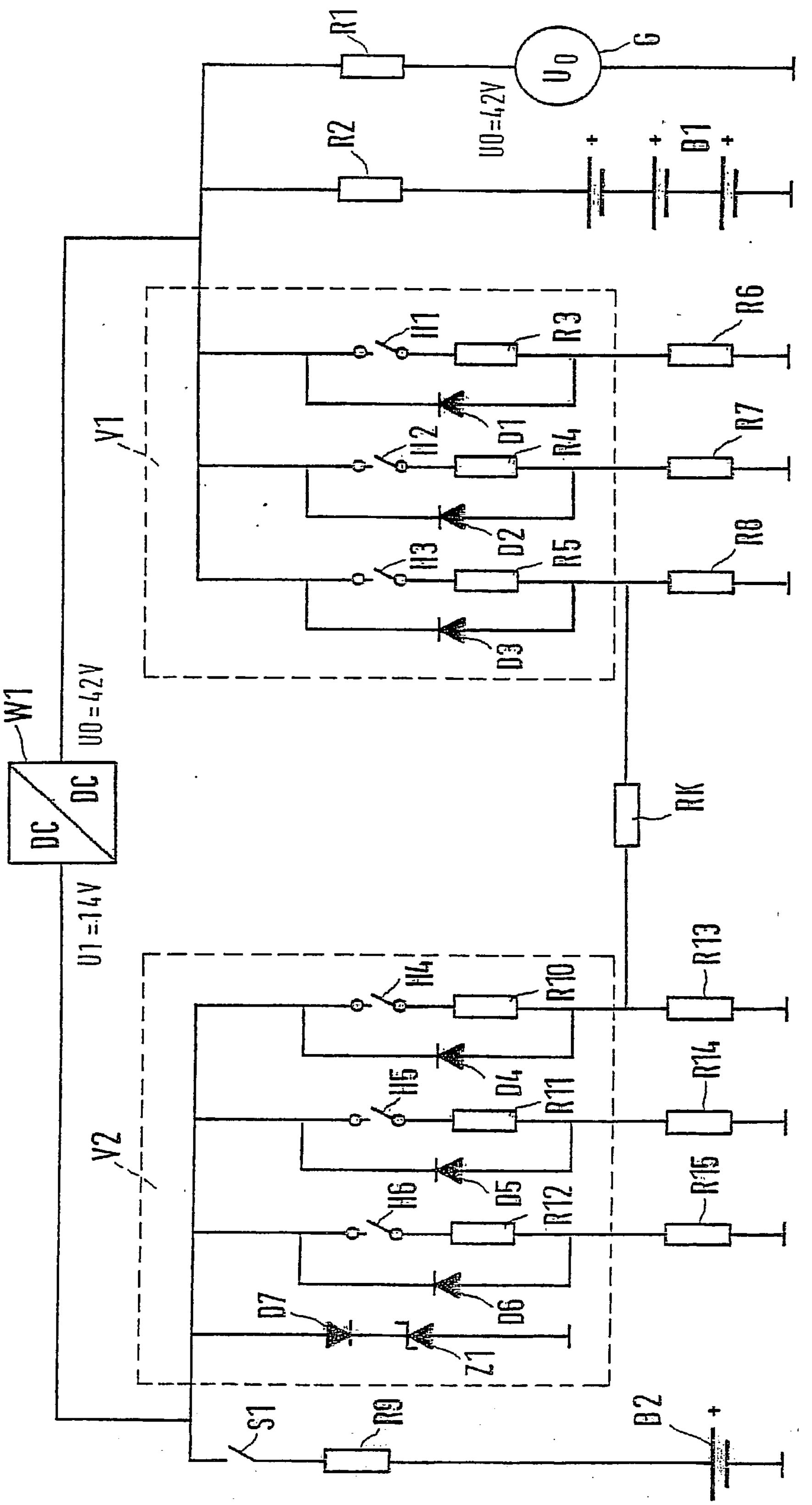
Figure 5 shows a protective circuit in which a power transistor 4, e.g. a MOSFET switching transistor having an integrated free-wheeling diode 7 is used. Power transistor 4 is controlled by a comparator 1 whose one input 6 receives a reference voltage Uref. Second input 5 of comparator 1 is connected between the series connection of resistors 2 and 3, resistor 2 being connected to terminal KL30 and resistor 3 being connected to terminal KL31. Terminal KL30 corresponds to the 12V or 14V terminal of a conventional on-board electrical system, while terminal KL31 corresponds to the ground line.

The mode of operation of the circuit may be explained as follows. The voltage on the 14V terminal is sent to ground terminal KL31 over the voltage divider having resistors 2 and 3. The voltage applied between two resistors 2 and 3 is measured and sent to the input of comparator 1 and compared with reference voltage Uref. Voltage U2 at resistor 3 drops as a function of the current flowing across resistors 2, 3. If this voltage U2 sent to comparator 1 exceeds preselectable reference voltage Uref, power transistor 4 which is activated becomes conducting and therefore limits the voltage to the level defined by resistors 2 and 3. A certain voltage may thus be preselected through the choice of resistors 2 and 3. Power transistor 4 thus forms an active voltage limiter.

If the on-board electrical system is supplied with a negative voltage, reverse diode 7 of charging voltage is switched to conducting. Then the threshold voltage of reverse diode 7 is established as the maximum negative voltage in the on-board electrical system. This value may be preselected. The reverse diode thus assumes a protective function, which may have the advantage in comparison with a possible combination with a Zener diode that a narrower tolerance band may be established for the voltage. The circuit in Figure 5 may make it possible to limit a short circuit as well as negative voltages to advantage.

ABSTRACT OF THE DISCLOSURE

A multi-voltage on-board electrical system including at least two voltages different from ground, e.g., 14V and 42V, is described, in which a generator, e.g., the electric generator of a vehicle, generates one of the voltages, and the other voltage is formed from the first voltage by a converter. The two voltages are used to supply two different d.c. systems. An arrangement is provided as short-circuit protection between the two voltage levels, largely reducing the risk of a short circuit and/or the effects of a short circuit between the two voltages and/or protecting or disconnecting at-risk consumers in the event of a short circuit. In addition to the short-circuit protection, an overall concept of an electric battery and power management system is also obtainable for the multi-voltage on-board electrical system.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RK
R13
R10
H4
D4
R14
R11
H5
D5
R15
R12
H6
D6
V2
D7
Z1
S1
R9
B2

Fig.1

Fig.2

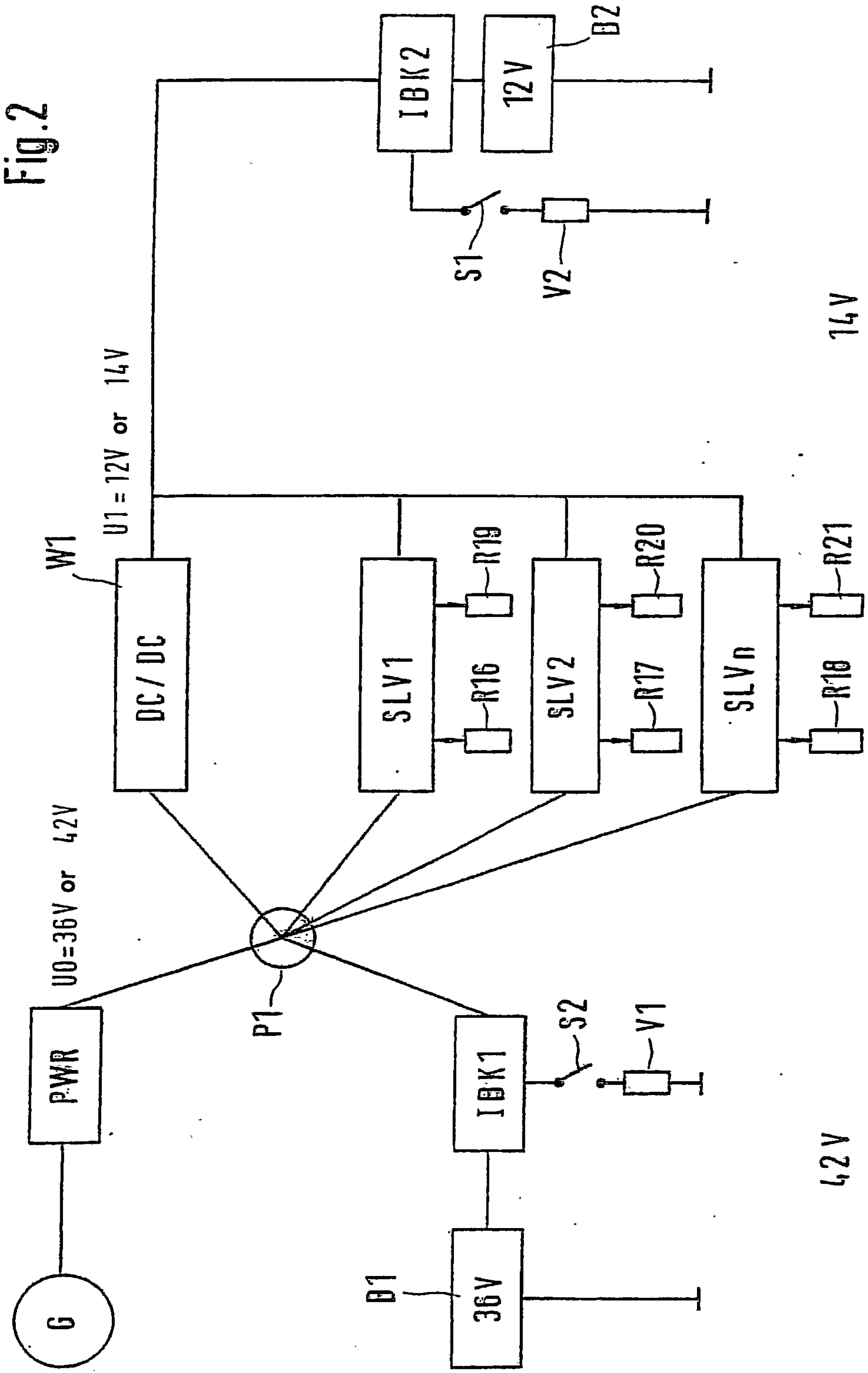

G
PWR
U0=36V or 42V
P1
IBK1
S2
V1
36V
B1
42V
DC / DC
W1
U1 = 12V or 14V
SLV1
SLV2
SLVn
R16
R17
R18
R19
R20
R21
IBK2
12V
B2
S1
V2
14V

Fig.3

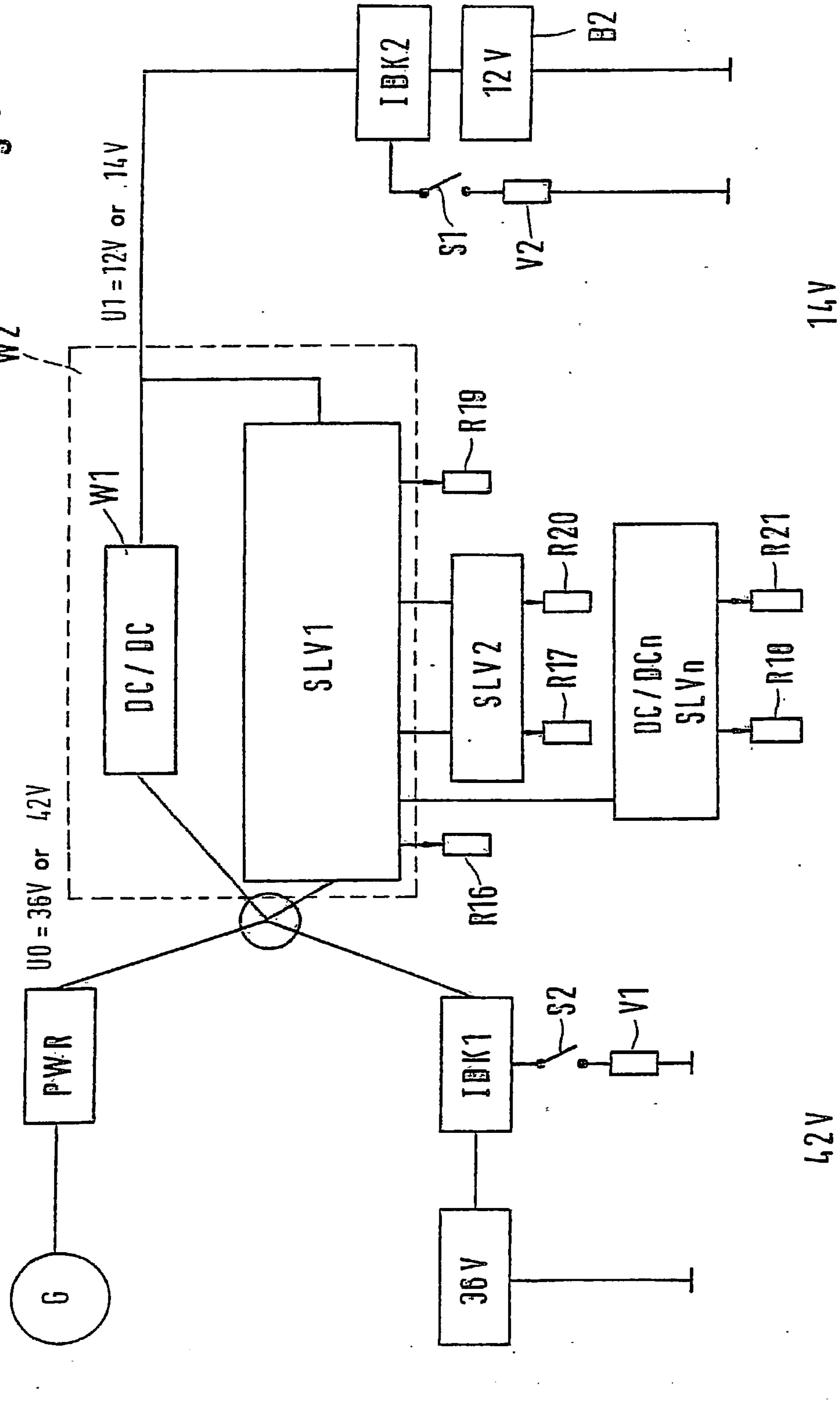
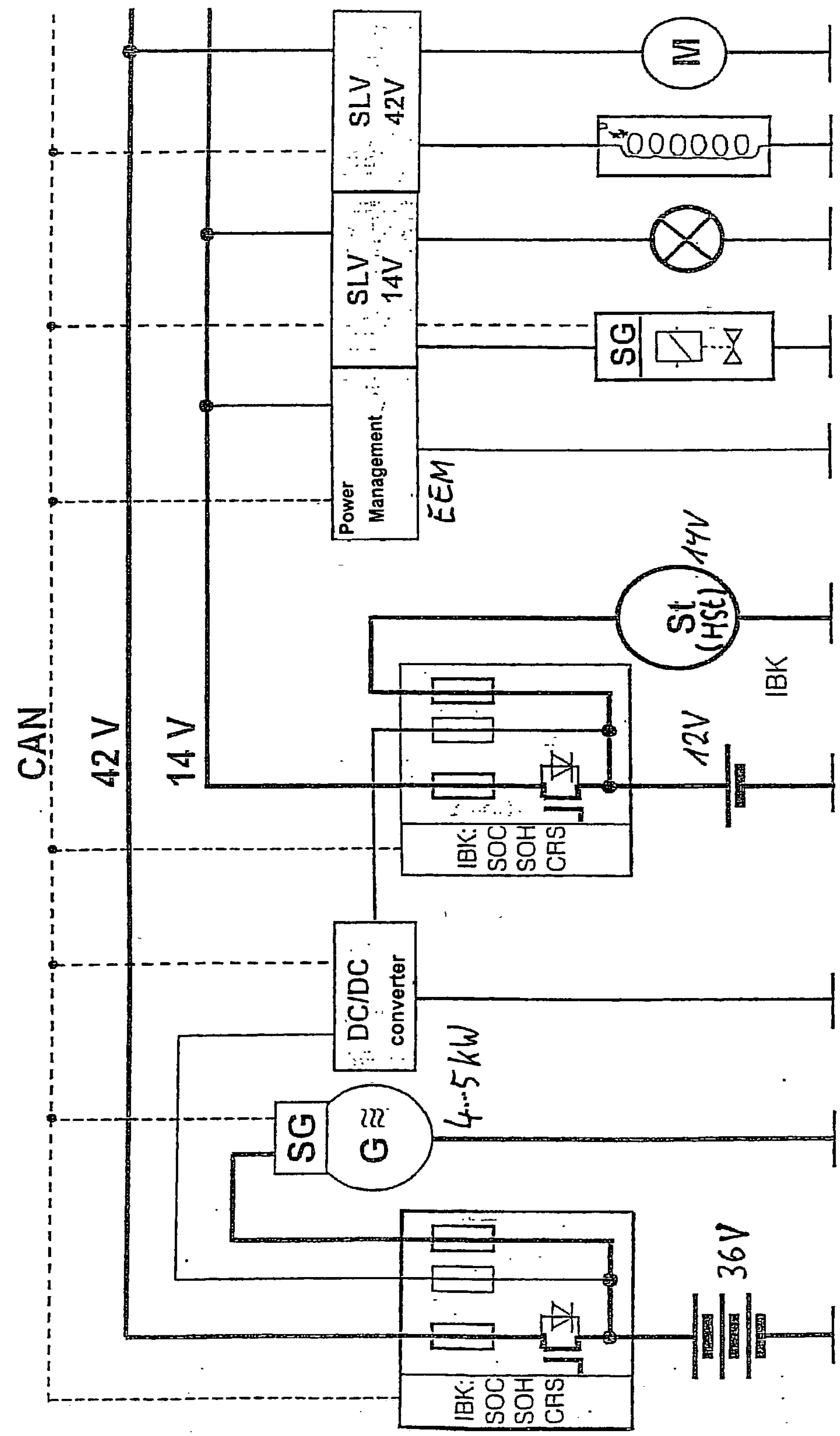

W2
U1 = 12V or 14V
IBK2
12V
B2
S1
V2
14V
W1
DC/DC
SLV1
R19
SLV2
R20
R17
DC/DCn
SLVn
R21
R18
U0 = 36V or 42V
R16
PWR
IBK1
S2
V1
42V
G
36V

Fig.4


CAN
42 V
14 V
SLV 42V
SLV 14V
Power Management
EEM
M
SG
St (HSt)
14V
IBK
12V
IBK: SOC SOH CRS
DC/DC converter
4...5kW
SG
G
IBK: SOC SOH CRS
36V

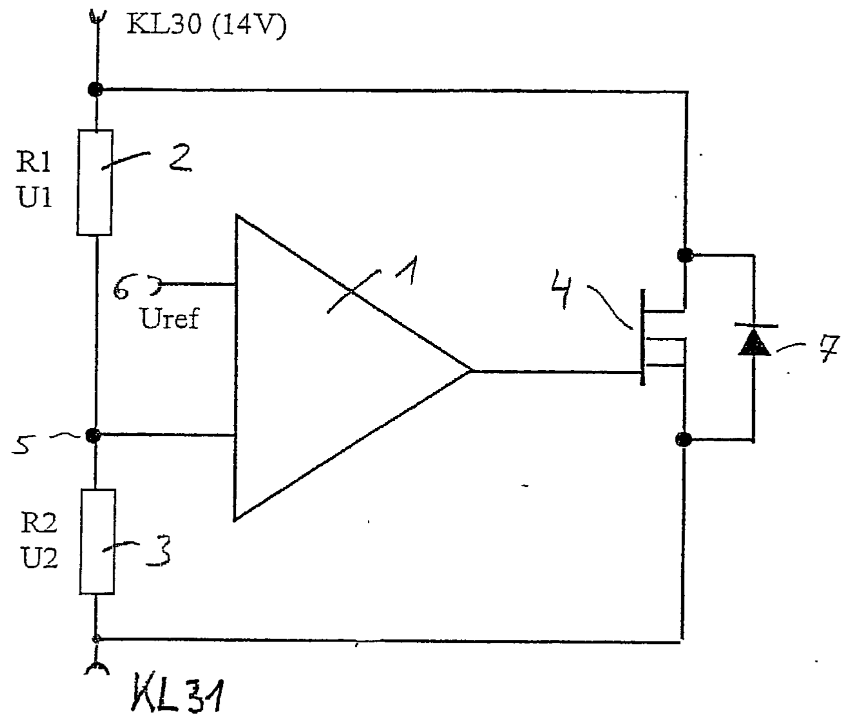



Fig 5

[10191/2344]

COMBINED DECLARATION AND
POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **MULTI-VOLTAGE ON-BOARD ELECTRICAL SYSTEM**, and the specification of which:

[ ] is attached hereto;

[ ] was filed as United States Application Serial No.
and,

[x] was filed as PCT International Application Number PCT/DE00/03249, on the $18^{TH}$ day of September, 2000

[ ] an English translation of which is submitted herewith.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

EL594613255

**PRIOR FOREIGN/PCT APPLICATION(S)**
**AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119**

Country : Federal Republic of Germany

Application No. : 199 44 833.7

Date of Filing: 18 September 1999

Priority Claimed
Under 35 U.S.C. § 119 : [x] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code § 120 of any United States Application or PCT International Application designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

**PRIOR U.S. APPLICATIONS OR**
**PCT INTERNATIONAL APPLICATIONS**
**DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120**

U.S. APPLICATIONS

Number :

Filing Date :

PCT APPLICATIONS
DESIGNATING THE U.S.

PCT Number :

PCT Filing Date :

I hereby appoint the following attorney(s) and/or agents to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith.

(List name(s) and registration number(s)):

| | |
|---|---|
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

FOO

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